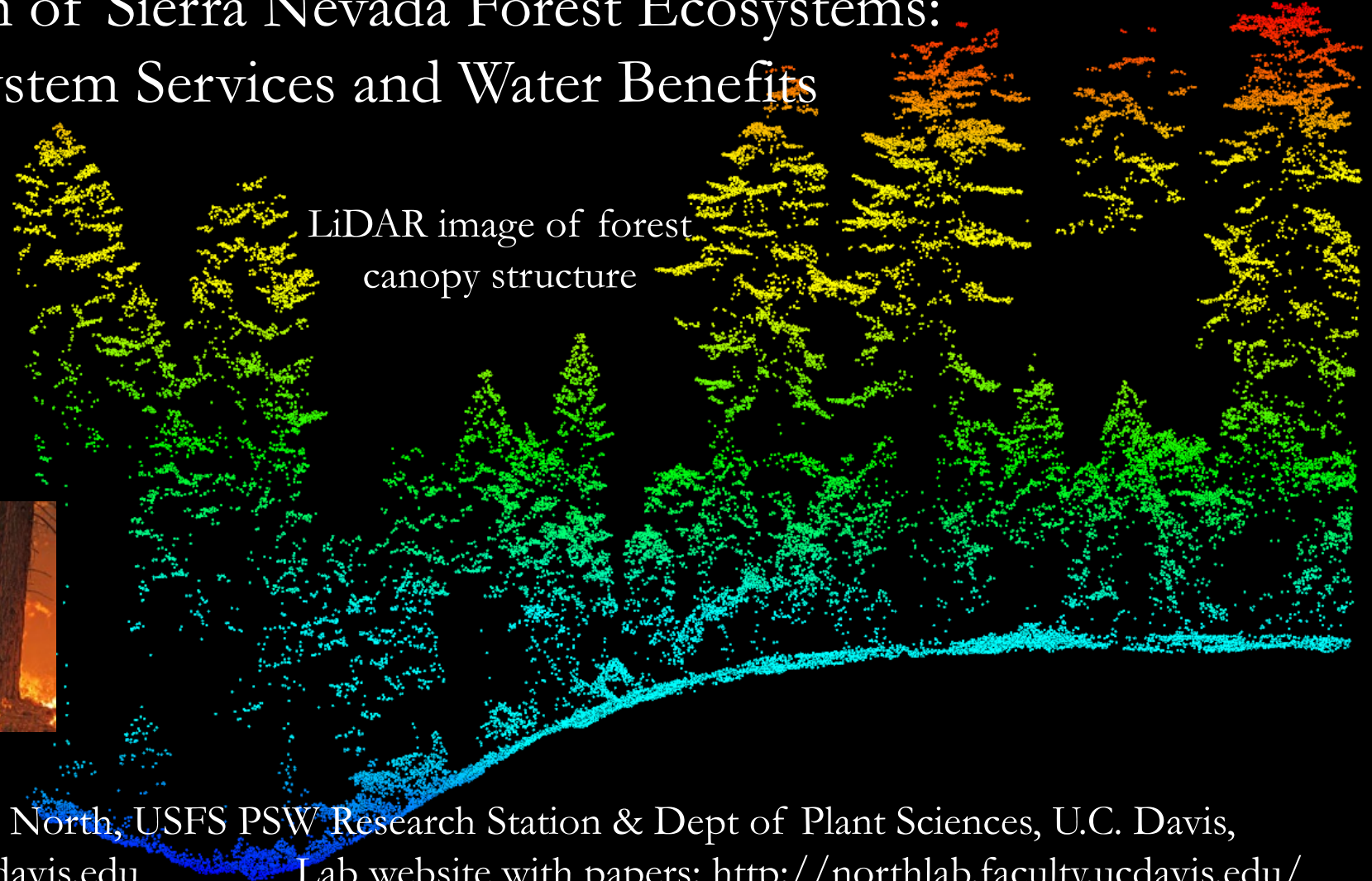# Restoration of Sierra Nevada Forest Ecosystems: Ecosystem Services and Water Benefits

LiDAR image of forest canopy structure

Malcolm North, USFS PSW Research Station & Dept of Plant Sciences, U.C. Davis, mnorth@ucdavis.edu   Lab website with papers: http://northlab.faculty.ucdavis.edu/

Fire Suppression Effect in Western Forests : Historic and Current Forest Conditions
Do nothing/hands off management is not an option
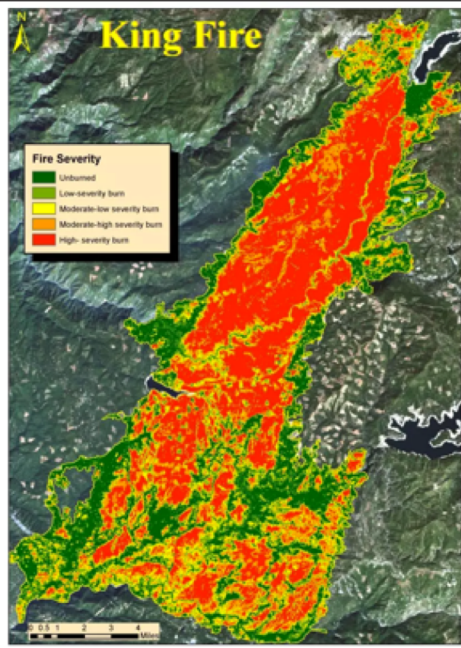

Historic
(pre 1870)

Time Period

Yosemite Valley

Current wildfires burn differently: large patches of high-intensity crown fires that kill most trees even the large, old ones.

Current
(after 1970)

Ecosystem Impact of Modern Wildfire:
Amount and Size of High Severity Patches has no Historical Analog

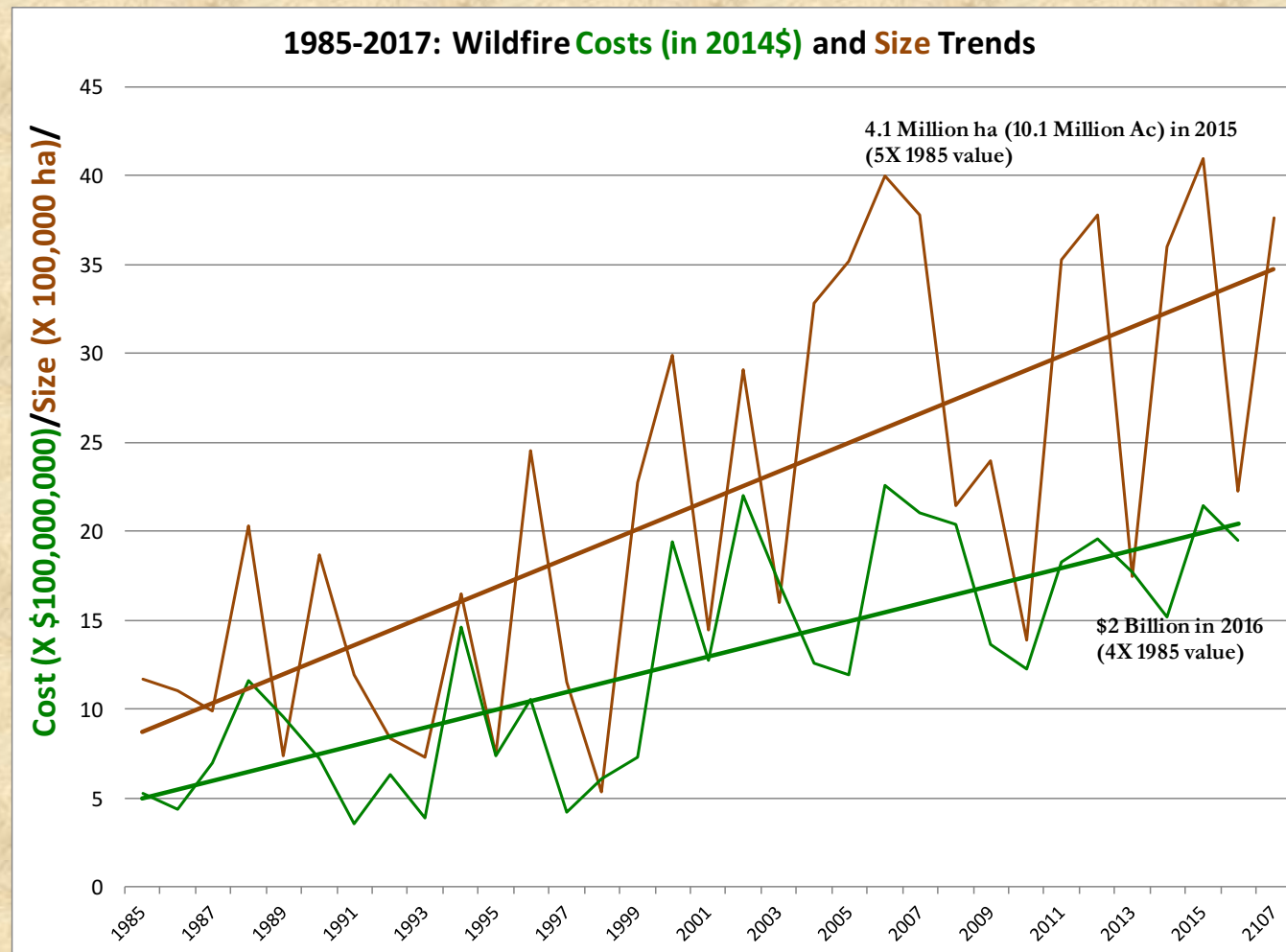

Before European arrival:
- High severity = 4-12% of fire area
- Patches rarely >10 ac

Current Fire Behavior:
- High Severity averages >35%
- Patches >1000 ac are common

➤ Interior of these high-severity patches is well beyond conifer seed dispersal
➤ Much of these areas may become long-term shrub fields
➤ **Both fire-suppressed and post-burn forests lack heterogeneity**

National Fire Trends: Even with the World's Best Fire Fighting Forces, Size, Cost and Severity of Wildfires is Increasing

1985-2017: Wildfire Costs (in 2014$) and Size Trends

Cost and size values are for federal agencies only

Cost (X $100,000,000)/Size (X 100,000 ha)/

4.1 Million ha (10.1 Million Ac) in 2015 (5X 1985 value)

$2 Billion in 2016 (4X 1985 value)

2017 Cost was a record high of $2.8 billion

Fire is inevitable in much of the Sierra Nevada. Not a question of *If*, but *When*

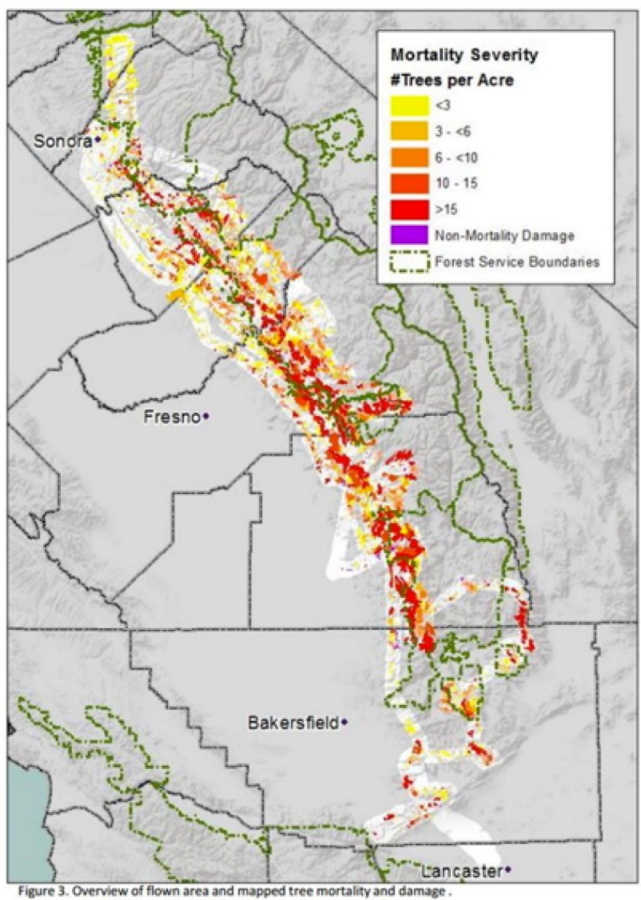# Dense Forest Resulting from Fire Suppression Is Not Only a Fire Problem: There are too many 'straws in the ground'

Figure 3. Overview of flown area and mapped tree mortality and damage.

Mortality Severity
#Trees per Acre
- <3
- 3 - <6
- 6 - <10
- 10 - 15
- >15
- Non-Mortality Damage
- Forest Service Boundaries

➢ 2017: Tree Mortality from CA 5 yr drought >129,000,000 dead trees in the Sierra Nevada

➢ Beetle mortality is particularly accelerating the **loss of large, tall, old-growth trees**

If the Problem is Known, How are We Doing?
Current Pace and Scale on National Forests in the Sierra Nevada

Historical Rate of Fire	487,486 ac/yr
Current Rates of Treatment* (1998-2008)	36,854
• Mechanical treatment	28,598
• Prescribed fire	8,256
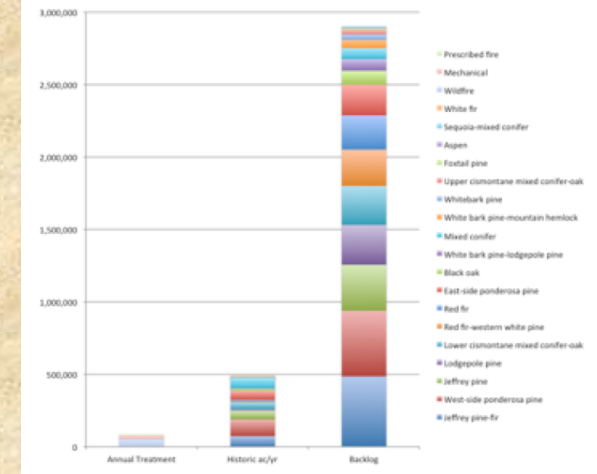
➔ **Current treatment is 7.6% of historical rate**

➔ **Annual Deficit = 450,000 acres/yr**

➔ **Wildfire has largest impact at >120,000 ac/yr but high severity**

North et al. 2012. JF 110: 392-401

Permanent Backlog:
- **Because you need to maintain a reduced fuel condition, it eats up all of your effort**
- **At current pace, 2.9 million acres (>60% of FS acreage) will never get treated**

What's the Hold Up? One Main Cause is How to Thin the Forest and Still Provide 'Sensitive' Species Habitat: Dense Forests with High Canopy Cover:

• The goshawk, spotted owl and fisher are all associated with dense, fuel loaded conditions

• Mechanically thinning, used to reduce fuels sometimes simplifies forests conditions

• Some stakeholders have repeatedly litigated projects

• Even when not litigated, the EA/EIS process slows projects and limits size (<3000 ac when should be 30,000 ac)
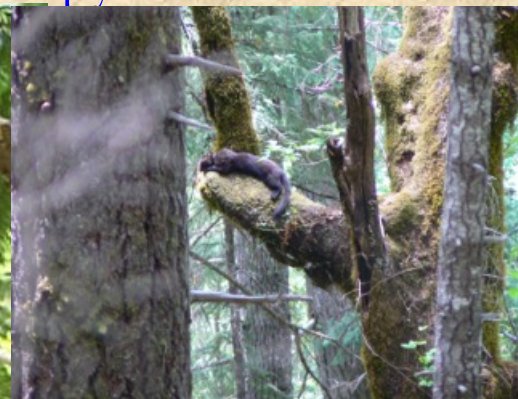
Fuels Reduction vs Wildlife Habitat vs Drought Res.

We cannot seem to resolve these competing objectives

Untreated forest infilled with fuels and too many stems from fire suppression

Example of a fuels treatment that removes all understory and ladder fuels, a condition sometimes referred to as a "clearcut from below".

• The problem has been to identify where, how and at what scale forest conditions should vary to meet fuel, wildlife & restoration objectives

Forest structure in an active-fire stand in Yosemite

How Research Can Help. Within Stand Spatial Variability: Ecosystem Processes Linked to Structural Heterogeneity
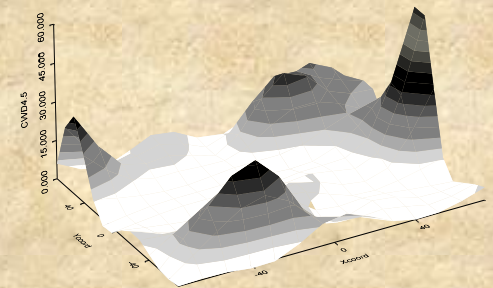
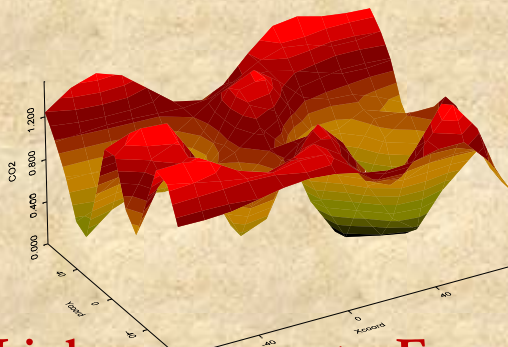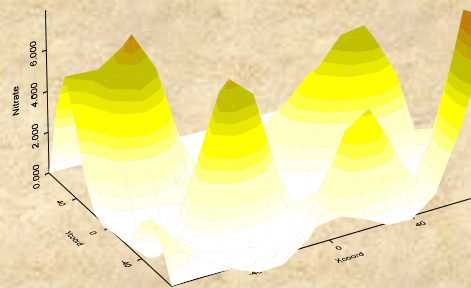**Vegetation Structure:**

Forest Canopy Gaps
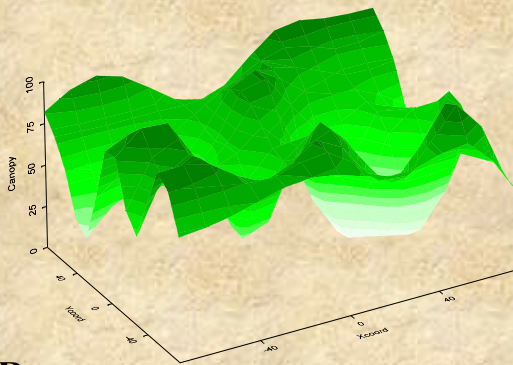
Ceanothus Cover
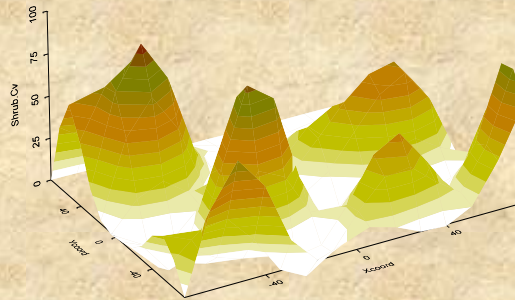
Litter Depth

Mapped 10 ac plots

Ecosystem Process:

PAR

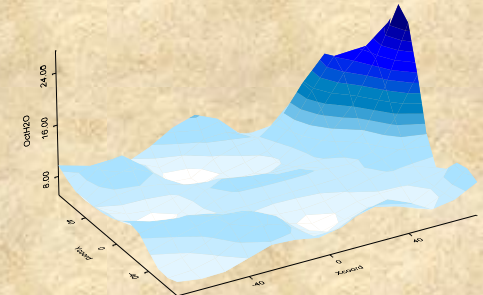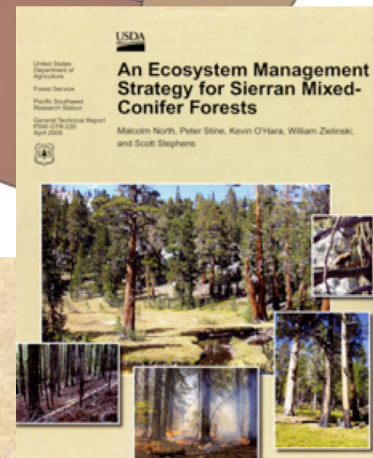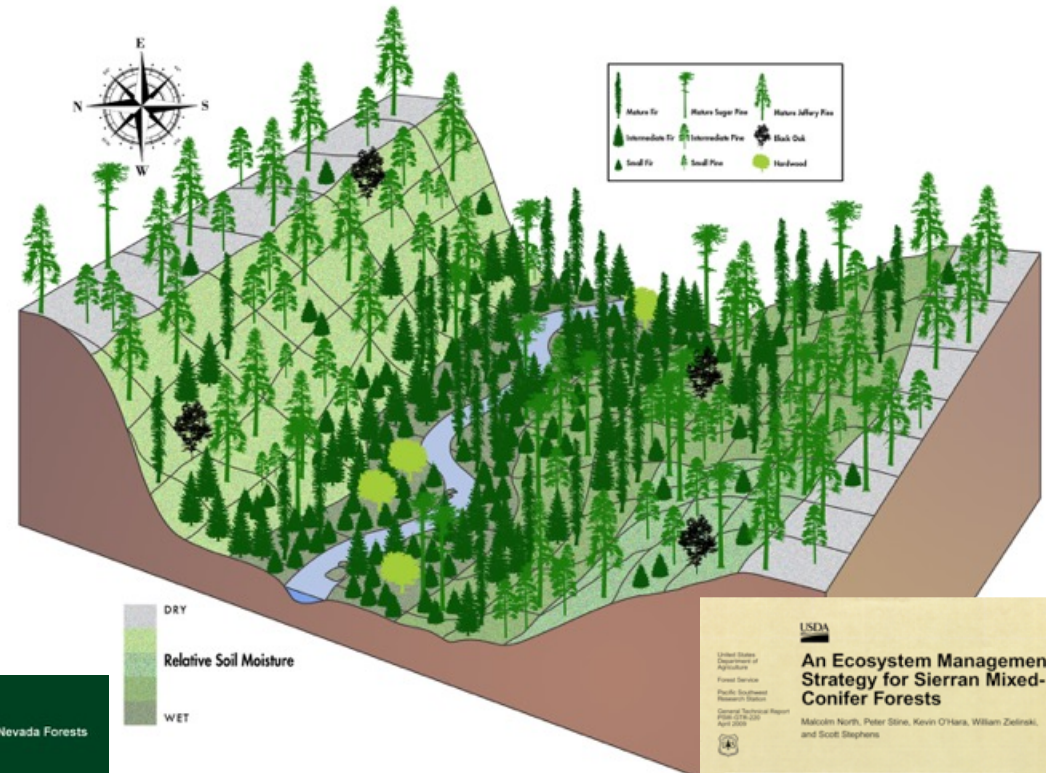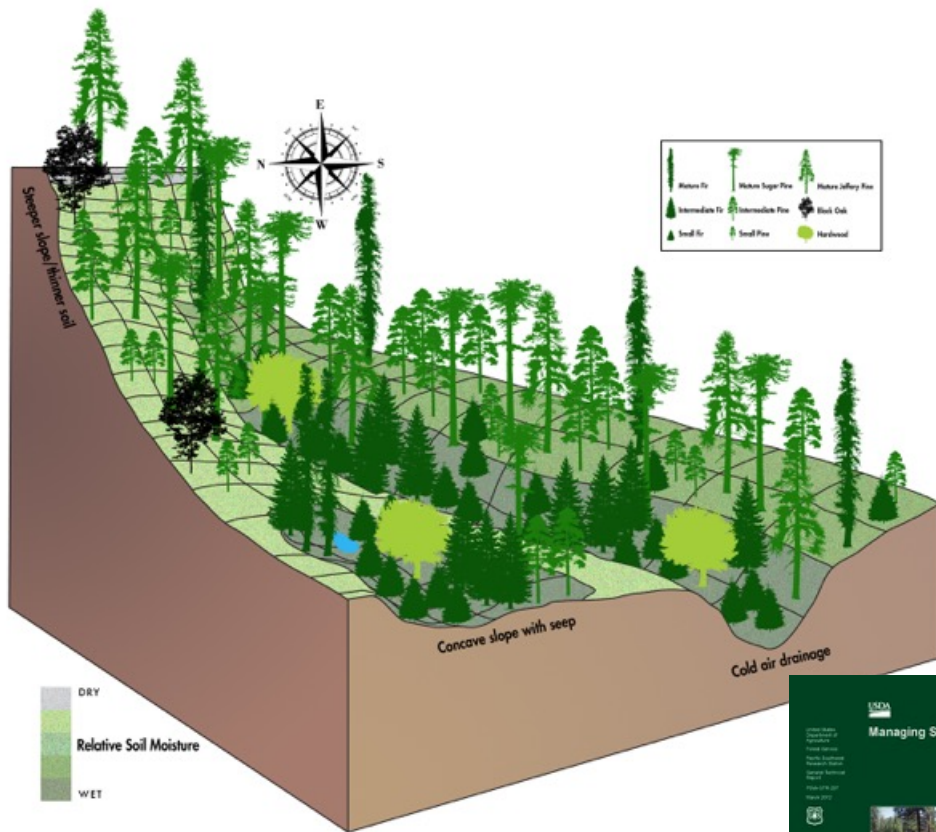**Available Nitrogen**

Soil Moisture

Linkage suggests: Forest heterogeneity supports biodiversity and ecosystem resilience

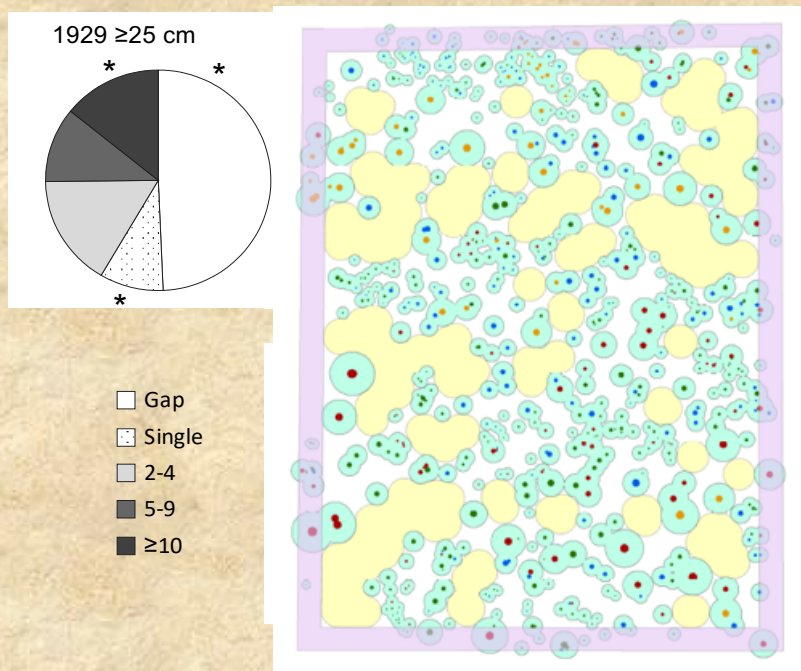# Proposed Strategy: Use Topography to Create Forest Heterogeneity

Pattern of Within Stand Forest Heterogeneity Common to Frequent-Fire Forests
ICO (**I**ndividual trees, **C**lumps of trees, **O**penings)

Map of Historic (1929) Forest Structure:
Note 50% of area in gaps

Effect on Water

Recent studies & models suggest ICO pattern may increase H_2O yield by 15-20%

Small gaps let more snow reach the ground, reducing canopy snow sublimation losses and adjacent trees provide shade slowing ablation

1929 ≥25 cm

☐ Gap
▨ Single
▨ 2-4
▨ 5-9
▨ ≥10

Canopy Cover = 37%

Lydersen, J.M., M.P. North, E.E. Knapp, and B.M. Collins. 2013. Quantifying spatial patterns of tree groups and gaps in mixed-conifer forests: reference conditions and long-term changes following fire suppression and logging. Forest Ecology and Management 304: 370-382.

Questions?